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A SURVEY OF ROAD CONSTRUCTION AND MAINTENANCE PROBLEMS IN CENTRAL ALASKA

E.F. Clark and O.W. Simoni

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A survey of road construction and maintenance problems in central Alaska is presented. The problems of poor fill and foundation material, permafrost degradation under pavement and shoulders, slope instability, water erosion, road icing from subsurface seepage, and culvert icing are described. Possible solutions to road maintenance problems in central Alaska include the use of insulating materials in permafrost areas, MESL construction when non-frost-susceptible soils are unavailable, and the use of improved drainage in areas where

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Cont. extensive icing occurs. Bridge damage, erosion of sidehill cuts and embankment instability are also discussed and potential solutions are given.

CONTENTS

PREFACE

This report was prepared by E. F. Clark, formerly Chief, Alaskan Projects Office of the U. S. Army Cold Regions Research and Engineering Laboratory, and O. W. Simoni, Research Civil Engineer, Foundations and Materials Research Branch, Experimental Engineering Division, CRREL.

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The authors wish to express appreciation to members of the Alaska Department of Highways, and especially to David Esch for information and many helpful suggestions. The Alyeska Pipeline Service Company also provided much useful information which was considered in preparing the report. Special appreciation is expressed for drafting by Michael Stallion and for photography by Paul Lynne.

SUMMARY

In March 1973, the Alaskan Projects Office at CRREL initiated a program to evaluate cold weather construction in Alaska. The research concentrated on difficult road construction problems in Alaska and other cold environments that are characterized by permafrost, deep seasonal frost penetration, and severe icing conditions. The objectives of the research were to identify and define the more significant road construction problems in Alaska, and to document these problems and identify promising research approaches.

The research program consisted of 1) a literature search (including personal contacts with the Federal Highway Administration, the Alaska State Highway Department, the University of Alaska, Alyeska Pipeline Service Co., and R&M Engineering and Geological Consultants, 2) highway reconnaissance trips to observe and document areas showing severe distress or failures, such as settlements, frost heave, surface degradation, drainage, slides, etc., 3) the identification of known or probable causes of road failures and the selection, analysis and evaluation of pertinent data obtained, and 4) the preparation of a final report, documenting results of the investigations, and recommending research considered to offer promise of meaningful results.

It was concluded that three major types of road construction problems exist in Alaska: 1) frost-susceptibility of earth materials in road embankments, 2) permafrost degradation under road embankments and shoulders, 3) high water erosion and culvert icing. Potential solutions are given for these problems and research recommendations are made. Discussion is given to MESL utilization, the use of insulation and berms to prevent permafrost degradation, methods of preventing culvert icing, the design of bridges to minimize damage from ice and debris, methods of maintaining slope stability, and techniques for improving site selection.

A SURVEY OF ROAD CONSTRUCTION
AND MAINTENANCE PROBLEMS IN CENTRAL ALASKA

by

E. F. Clark and O. W. Simoni

SECTION I - INTRODUCTION

Purpose and Scope

This report describes some of the more significant road construction and maintenance problems in central Alaska, and suggests possible research approaches in seeking acceptable solutions. Though by no means all-inclusive, this report is based on an extensive literature review, on observations by the authors of road performance during the 1973 spring melt and breakup season, and on discussions with representatives of the Alaska Department of Highways and the United States Federal Highway Administration. Most of the actual on-site observations of road performance were made in the vicinity of Fairbanks along the Richardson, Steese, and Elliot Highways, the Chena Hot Springs Road, and along the Trans-Alaska Pipeline Service Road from Livengood to the Yukon River (Fig. 1).

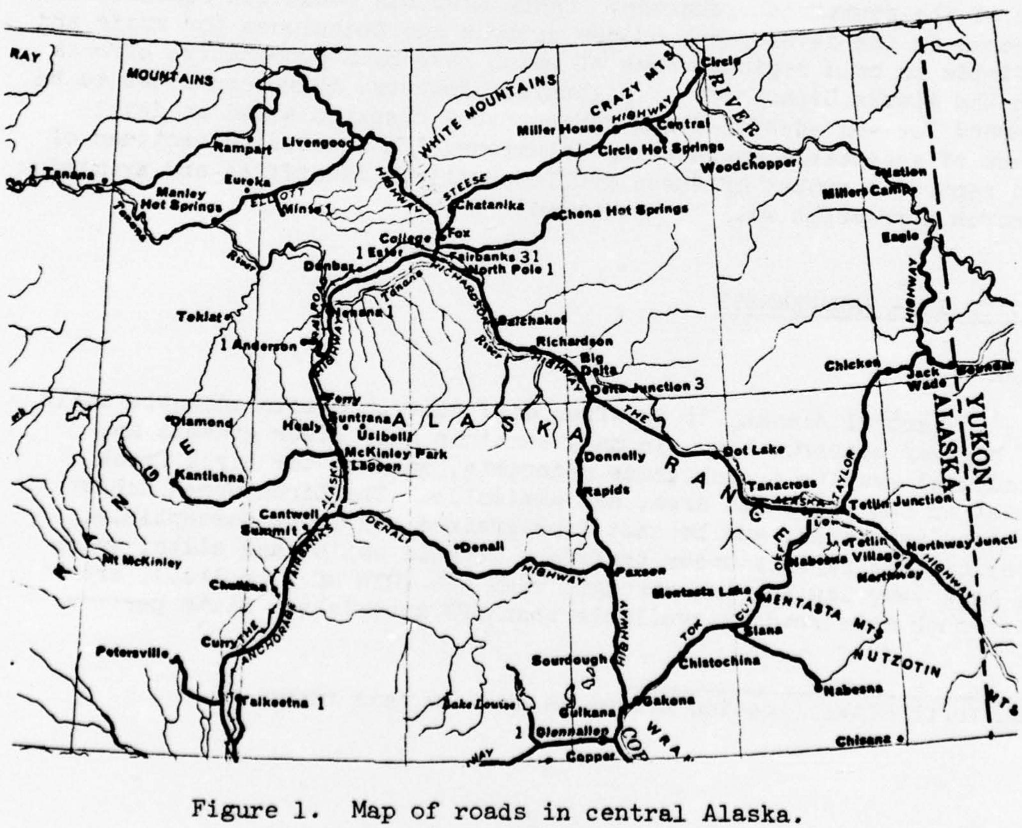

Figure 1. Map of roads in central Alaska.

Background

Alaskan road construction and maintenance encounter not only the usual problems found in the contiguous United States but also those imposed by the harsh climate of the Arctic and Subarctic. The Alaskan climate allows only a short working season and presents the additional problems of extreme winter icing, permafrost degradation and substantial runoff during the spring season.

The highway system evolved from the trails made by early fur traders, gold miners and settlers and from development during the military build-up of World War II. Roads were often built with the pioneer engineering design of the times. Funds were usually inadequate, (U.S. Dept. of Interior 1957), and recent natural disasters, such as the earthquake of 1964 and the Fairbanks flood in 1967, seriously set back the Alaskan highway program for several years (Alaska Construction and Oil 1969).

For a number of years the Alaska Department of Highways and the Federal Highway Administration have maintained a comparatively small but continuing program of investigations to improve highway design criteria. These investigations have been addressed to such problems as classification of natural road building materials, prevention of culvert icing, measurement of subgrade temperature, maintenance of slopes and insulation of the permafrost subgrade. CRREL also has conducted considerable research in the development of new methods and techniques for roads and airfields in cold regions, some of which have been cooperative efforts with the Alaska Department of Highways. However, there continues to be a demand for well-designed and concentrated research aimed at development of acceptable engineering solutions. In succeeding sections of this report, a number of these problems will be identified and promising research approaches will be discussed.

SECTION II - EMBANKMENTS

Soils

In central Alaska, it is often difficult to obtain adequate soils for highway construction. In many sections only river gravels and decomposed granite or schistose materials, such as the Birch Creek Schist in the Fairbanks area, are available. The Birch Creek Schist is badly weathered, and becomes fine-grained and frost susceptible, deteriorating rapidly under traffic. Organic soils* and silts, which may have very low bearing strength when wet (CBR of 1 or less), are often much more readily available than NFS materials. Silts perform

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* Radforth classification system is used in this report.

acceptably well in embankments if the moisture content can be kept below optimum (less than 20%), if they are of high density, or if they can be kept frozen.

River gravel, which is often used when locally available and accessible, has two serious disadvantages: 1) it often has a poor grain size distribution because of water sorting during deposition, and 2) owing to its rounded particle shape it tends to shift under sustained vibratory loading. Accordingly, embankments composed exclusively of river gravel may be slow to stabilize and often require excessive yearly maintenance. These factors alone appear to provide strong justification for research on chemical stabilization of materials used in embankments.

A few roads have been built over soft organic materials (such as peat or muskeg), but these soils tend to flow laterally from under the embankment to one or both sides (as shown in Fig. 2) during trafficking. Current knowledge of peat and muskeg classification and properties, and current practices in testing and engineering construction are reported in Robison and Dodd (1962) and Philainen (1965). The prevalance of peat and muskeg throughout the Subarctic seems to justify an increase in research aimed at development of better design and construction criteria for its use.

Scarcity of clays or other material suitable for use as a binder in gravel surfacings poses additional problems throughout Alaska. Dust and stones thrown by tires make travel hazardous and expensive (due to broken windshields, damage from dust ingestion into engines, etc.). Effective dust palliatives are too expensive, however, for extensive usage.

Permafrost and Seasonal Frost

Approximately 80% of Alaskan terrain is underlain by permafrost (Black 1954). North of the Brooks Range, the permanently frozen ground is continuous and cold (i.e. 12°F to 14°F). In central Alaska the permafrost is discontinuous and classified as warm (28°F to 31°F). Figure 3 shows the approximate permafrost distribution in Alaska. The top of the perennially frozen soil is generally from 2 to 12 ft below the surface in central Alaska, depending upon the type of covering soil, vegetative cover, amount of sunlight received, depth of water table, average winter snow cover, and a number of other variable factors.

Warm permafrost is in a precariously balanced state of equilibrium. Any changes in the surface, such as forest fires, clearing of timber, road building, etc., can upset this balance and result in gradual degradation. This degrading or melting can continue over a period of decades before a new equilibrium is established.

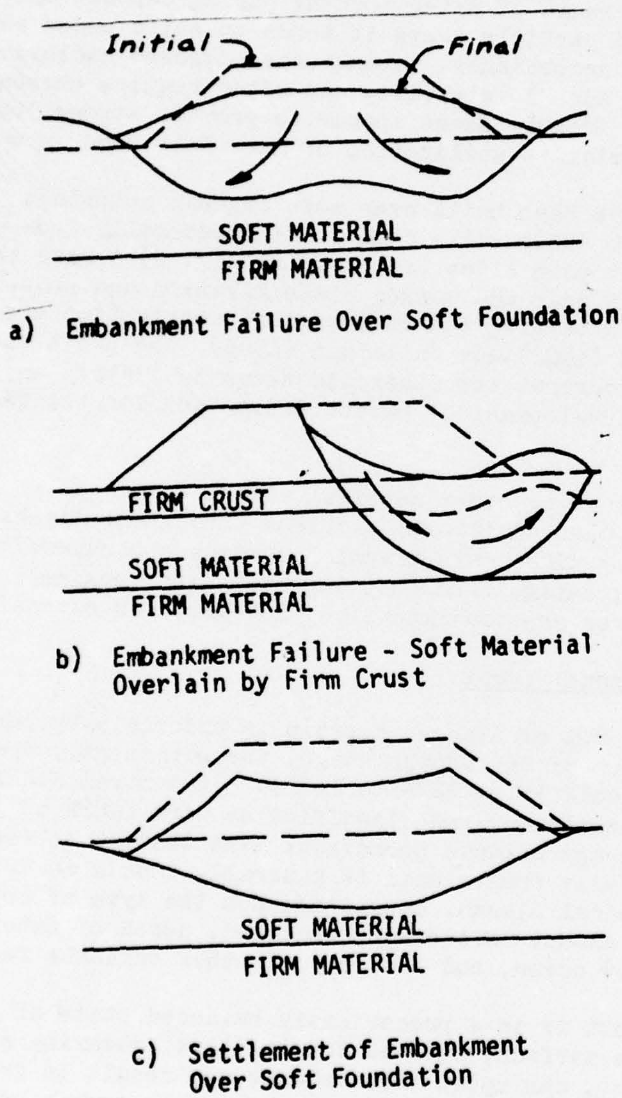

Figure 2. Typical embankment problems over soft foundations (Highway Research Board 1971).

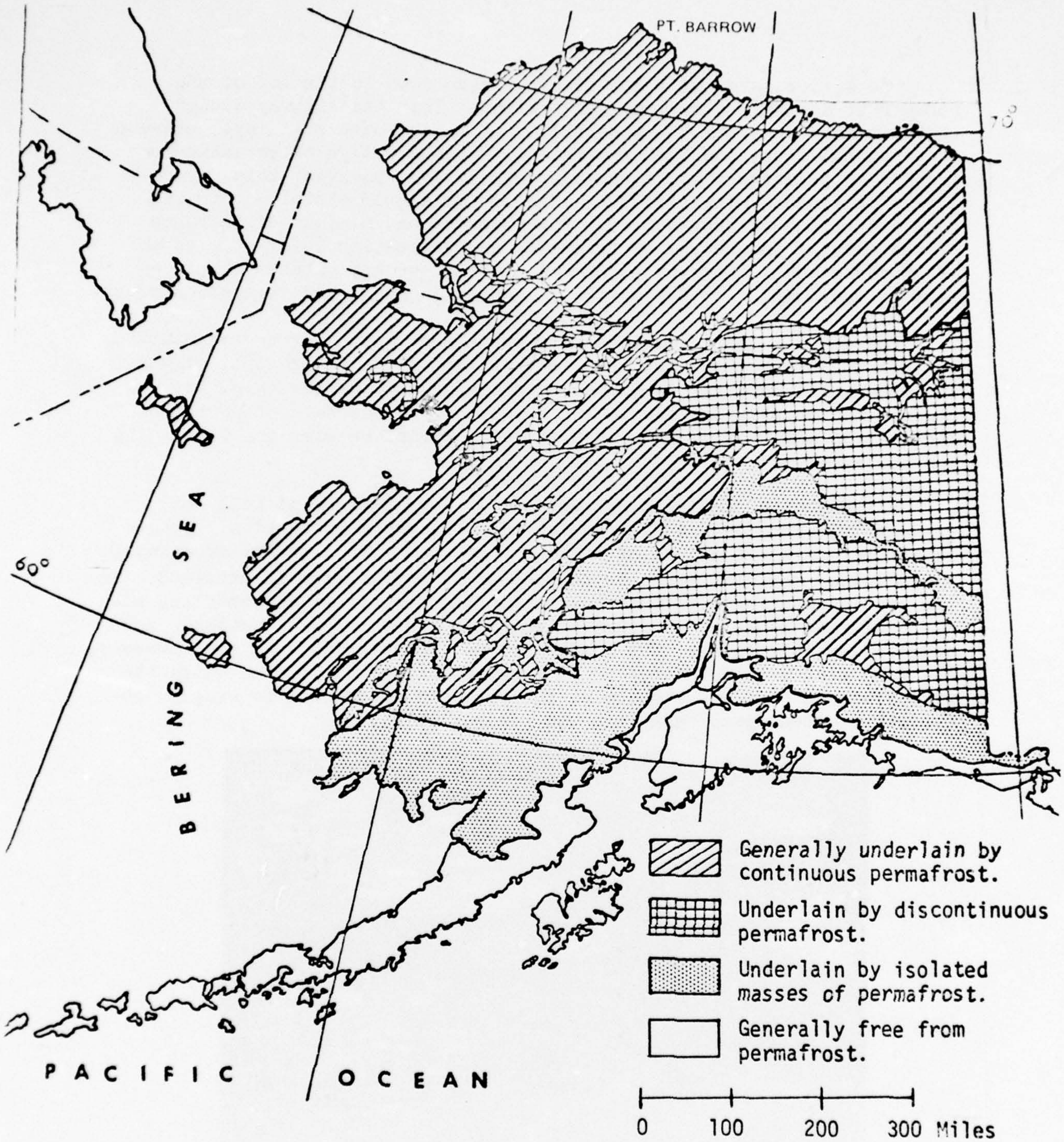

Figure 3. Permafrost distribution (Ferrians 1965).

The active layer will not always freeze down to the top of the permafrost during its maximum penetration. Thus the highway design engineer must consider the possibility of an unfrozen soil layer between the seasonal frost and the permafrost. Optimum design of embankments founded on permafrost would prevent degradation; however, this may not always be economically feasible. The design should minimize both the rate and extent of degradation. For this reason, minimum disturbance of the natural insulating surface soil and vegetation layer appears to offer advantages. Highway engineers usually specify embankment placement by end dumping on top of the undisturbed ground and vegetation cover.

End dumping is recommended over permafrost. The surface vegetation is left undisturbed but the trees are cut and laid in the right of way, and embankment material is dumped over the organic matter (Fig. 4). The organic matter provides insulation so as to slow the rate of permafrost degradation and it also acts as a filter material between the fine soils and the embankment fill.

Although end dumping slows permafrost degradation, it will not prevent it; therefore, engineers recommend staged construction. Staged construction is the method of building the road with a gravel embankment and allowing the permafrost to degrade until equilibrium is attained. As the road surface settles with the continuing permafrost degradation, additional road material is added to maintain the surface elevation. When equilibrium is attained, the road is paved. With this technique, however, the road must remain unpaved for a substantial period of time while the permafrost thaws. Unfortunately, the public's opposition to staged construction often discourages its use (Brewer 1976).

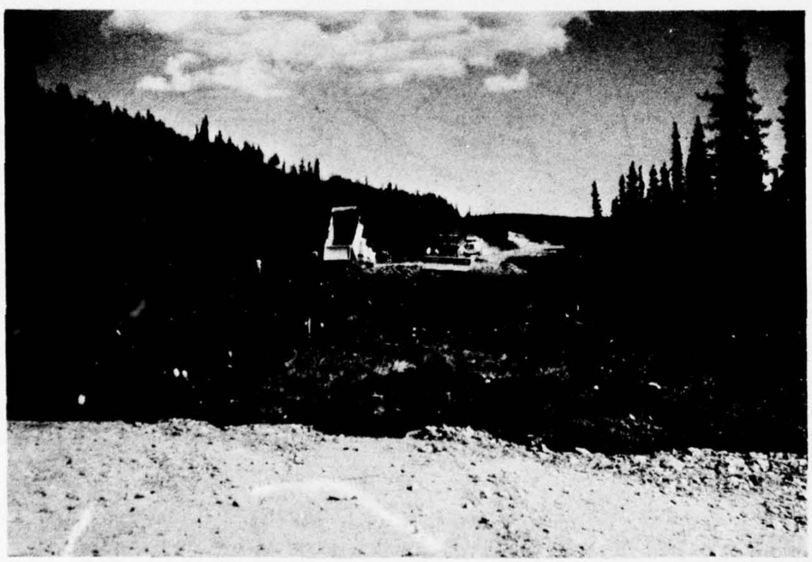

Figure 4. End dumping on Goldstream Road.

Use of Man-Made Thermoinsulating Materials

Use of thermoinsulating media within embankments offers promise of providing improved design to prevent frost heave in the seasonal frost zone and to retard or prevent degradation of the underlying permafrost (see Fig. 5). Berg (1973) explores in detail many possibilities of this technique. A number of tests have been conducted in

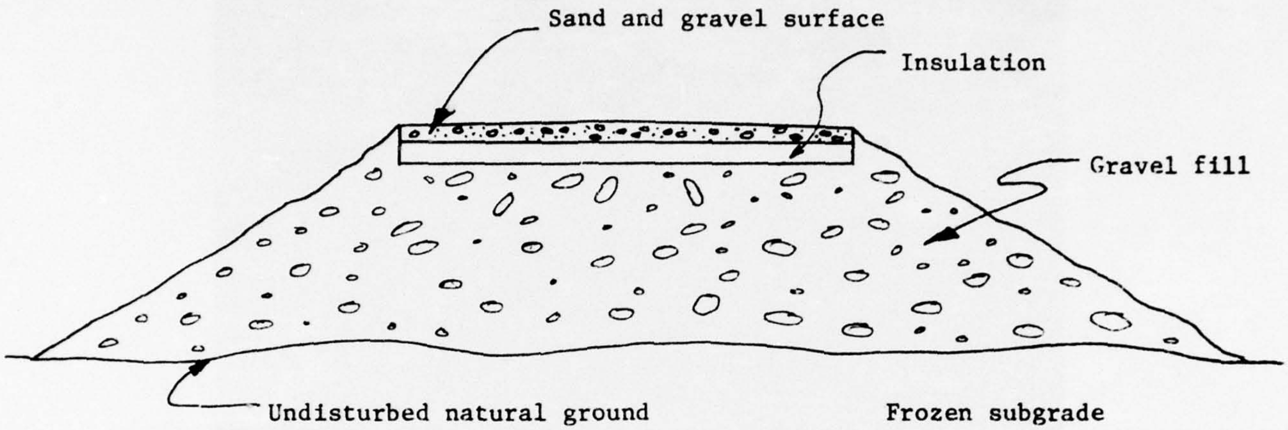

Figure 5. Schematic cross section using foamed insulation in the embankment (not to scale).

Alaska using various insulation materials, including foamed-in-place polyurethane, polystyrene boards, and Styrofoam* beads in both portland cement and sulfur matrices (Karalius and Smith 1973). CRREL, the Alaska Department of Highways, and the Alyeska Pipeline Service Company have experimented with foamed insulating materials in embankments. The Alaska Department of Highways used boards of Styrofoam in test sections in the vicinity of Chitina. The Department of Aviation also insulated a portion of the airfield runway at Kotzebue. Figure 6 shows a test section of foamed-in-place polyurethane in an expedient road at a CRREL site in Fairbanks, Alaska. In this application, prefabricated mats (called MOMAT) were placed over the insulating layers to spread the load and provide a wearing surface. Both of these sections were traffic tested during two successive summer seasons. The last traffic test was conducted in 1973, with rear axle loads of 29,000 lb and tire pressures of approximately 80 lb during each of 400 passes. Differential settlements of more than 12 in. occurred during the tests. Some of the test results are described by Smith et al. (1973). During the summer of 1972, the Alyeska Pipeline Service Company constructed and trafficked seven test sections containing an insulating layer in each of two "construction pads," one located near Fairbanks and the other near Glennallen.

*An extruded polystyrene

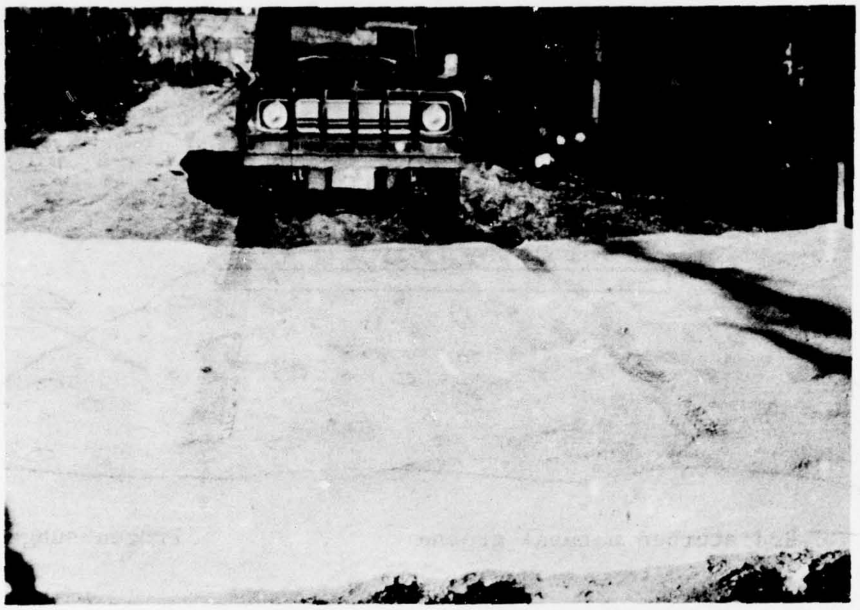

Figure 6. Foamed-in-place polyurethane (FIP).

In 1973, the Alaska Department of Highways constructed two road test sections on the Fairbanks to Anchorage Highway. The first section used a solid placement of polystyrene boards (Fig. 7). In the other test section, polystyrene boards were laid in a slotted configuration (called vane grid thermal insulation) as shown in Figure 8. The purpose of the slots was to permit heat to escape from the subbase during the cold season. Five feet of select material was placed over the polystyrene boards to allow normal highway traffic. The results of these tests are still inconclusive.

Berg (1973) has mentioned the concept of one-way insulation for use in road embankments to reduce permafrost degradation. One-way insulators are currently being used in the construction of the Trans-Alaska Pipeline and in other pile foundations. The technique of one-way insulation utilizes the heat pipe principle. Pipes, placed below the ground surface, transfer heat, either through convection or vaporization and condensation, to the atmosphere at ambient temperature. The system does not work when the ambient temperature is warmer than the permafrost - no heat is transferred into the ground.

Figure 7. Polystyrene boards laid over a subbase prior to placement of fill.

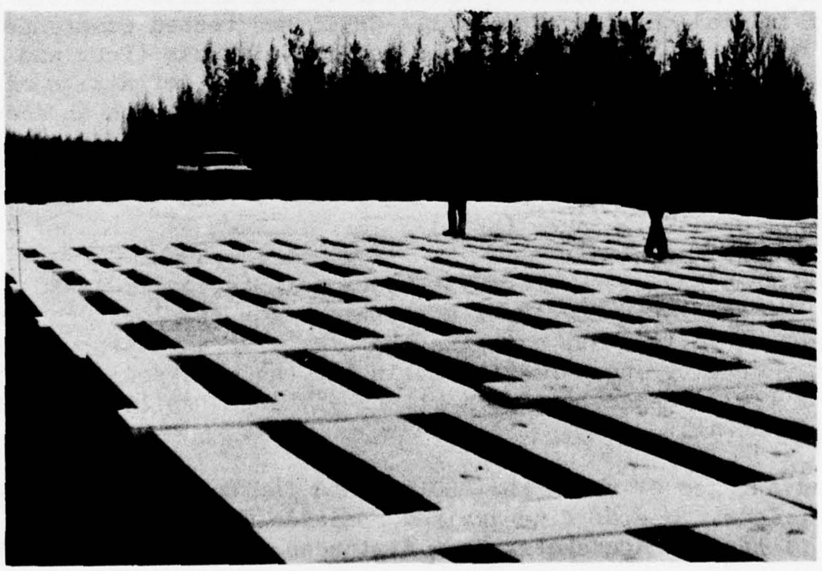

Figure 8. Polystyrene boards laid in a slotted configuration prior to placement of fill.

On the Richardson Highway near Birch Lake, the Alaska Department of Highways constructed test sections (in 1972) which used peat as a thermal insulating material. In this test 4 to 5 ft of frozen peat was placed over the subgrade, after which 3 to 4 ft of selected material was placed and compacted (Fig. 9). Thawing of the peat occurred and

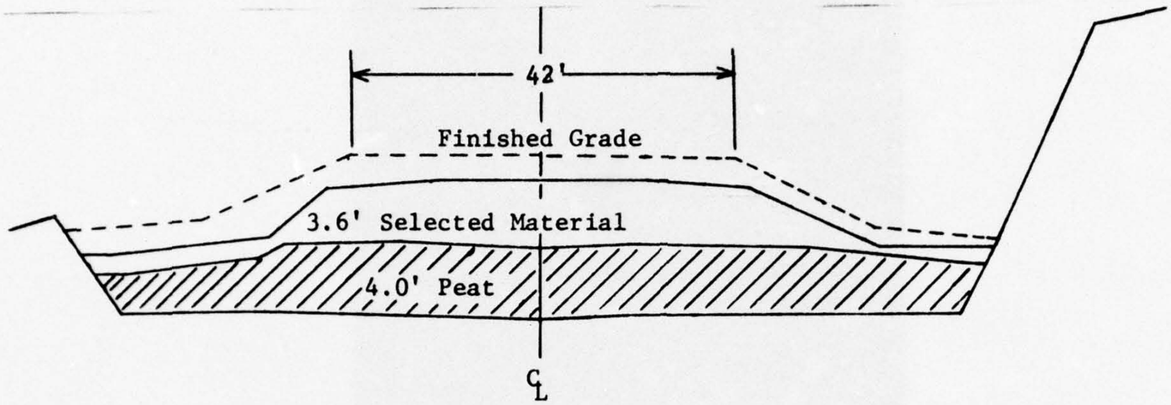

Figure 9. Cross section of peat test (near Birch Lake, Richardson Highway).

preliminary observations indicate that total settlements of less than 2 ft and a gradual lowering of the subgrade temperature under the peat have resulted. Since peat is abundantly available throughout Alaska and Canada, its use as an insulating material is attractive from the point of view of initial construction cost. CRREL has tested compressed peat blocks in an experimental road embankment in Fairbanks (Berg and Aitken 1973). However, additional tests are needed before definitive criteria and guide specifications for its use can be developed with an acceptable level of confidence.

Membrane-Enveloped Soil Layer (MESL)

The US Army Engineer Waterways Experiment Station (USAEWES), Vicksburg, Mississippi, developed a technique for enveloping a compacted layer of soils, such as silts and clays, in a waterproof membrane to sustain a density and strength within the enclosed soil. Joseph and Webster (1971) describe this membrane-enveloped soil layer (MESL) technique in detail.

The advantages of using the MESL method for base course construction are obvious. Use of fine-grained roadside material obviates the necessity of hauling aggregates long distances, and thus reduces both

construction time and cost. Since 1971, subsequent testing by USAEWES has proven that MESL base courses perform well and can be considered for use in both expedient and permanent road construction. Figure 10 is a conceptual cross section of a MESL base course.

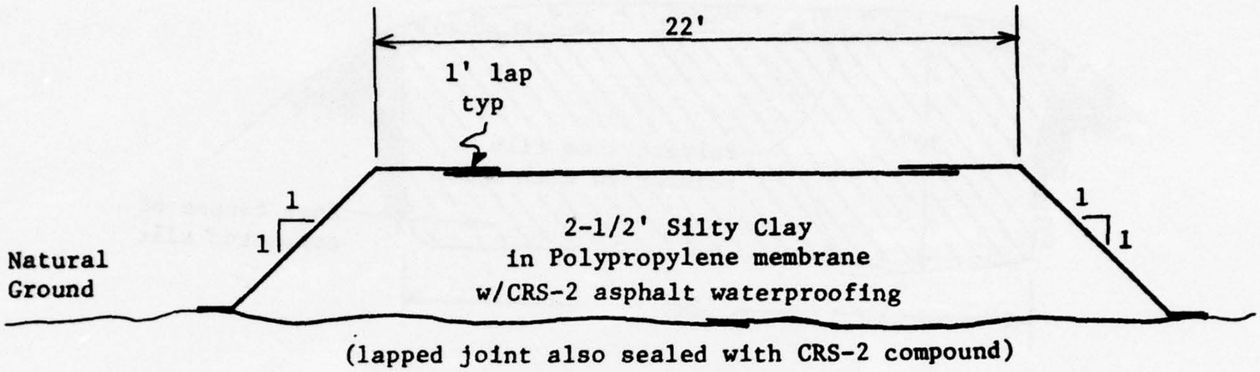

Figure 10. Schematic MESL cross section.

In 1970 CRREL constructed a MESL test section near Fairbanks, Alaska, using silt as the membrane-enveloped soil layer. The moisture content within the enveloped layer was approximately 13% when constructed, which is considered to be lower than the optimum range for Fairbanks silt. Polypropylene film treated with emulsified asphalt was used for both top and bottom membranes. A 1-1/2-in. blotter layer of sand was applied to the surface to provide protection for traffic testing. During the winter of 1970-1971 parts of the membrane were damaged by vehicles used to remove snow from the test section. As a result, during the spring thaw season water penetrated into the enveloped silt, and the moisture content in damaged areas rose to above 30%. Examination of the polypropylene membrane also revealed a multitude of tiny holes large enough to permit intrusion of surface water. The north end of the section, which was undamaged by snow removal equipment, withstood over 500 traffic passes of a loaded military dump truck with a gross weight of nearly 9 tons during the second and third spring thaw seasons without major damage (Smith and Paszint 1975).

In 1973, two additional MESL sections were constructed, one on a haul road to the sanitary fill on Fort Wainwright (Fig. 11). In this test polyethylene film reinforced with nylon fibers was used for both top and bottom membranes, and both were treated with emulsified asphalt (Schaefer 1973). The other section was constructed at Elmendorf Air Force Base near Anchorage. Smith and Karalius (1973) report in detail on construction of that test section. Traffic testing was to be accomplished by vehicles using these roads daily.

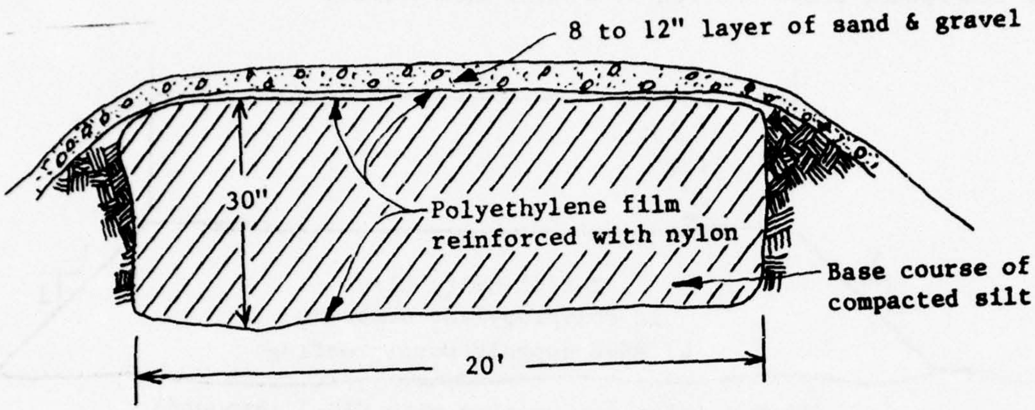

Figure 11. Schematic cross section of MESL expedient road.

Although, as previously stated, the MESL method offers potential economies in both time and initial construction cost, especially in areas where good granular materials are not available locally, it also has two distinct limitations. First, the fine-grained material must be enveloped at or below the optimum moisture content, which may be possible only during a short period of time during each year, unless elaborate drying procedures are employed. Secondly, care must be exercised during construction to prevent damage to the membrane by either mechanical equipment or by the material being enveloped (e.g., sharp rocks that would rip or puncture the membrane).

Embankment Stability

During the spring thaw and breakup season of 1973 an extensive effort was made to document photographically highway embankment failures in the vicinity of Fairbanks, Alaska. Most of the failures were in three general categories: 1) settlements caused by degradation of the underlying permafrost, 2) surface degradation caused by excessive moisture in the base course, and 3) loss of bearing capacity of a fine-grained soil base course when saturated with water during the spring melt and runoff season. The latter type of failure generally is compounded by poor drainage design.

The length of time required for an embankment founded on permafrost to stabilize is highly variable. It depends on many factors such

as amount and type of fill material used, amount of direct sunlight falling on the surface, freezing index, color of the road surface, local hydrology, etc. To assist in providing partial answers to these questions, CRREL constructed several test sections near Fairbanks at the Farmer's Loop Road Field Station. They were constructed over poorly drained muskeg where water ponds at the roadside each spring during the melt season. The vegetation was removed by a bulldozer before the embankment and surfacings were placed (Fig. 12). Figure 13 shows the completed

Figure 12. Test site after removal of vegetation.

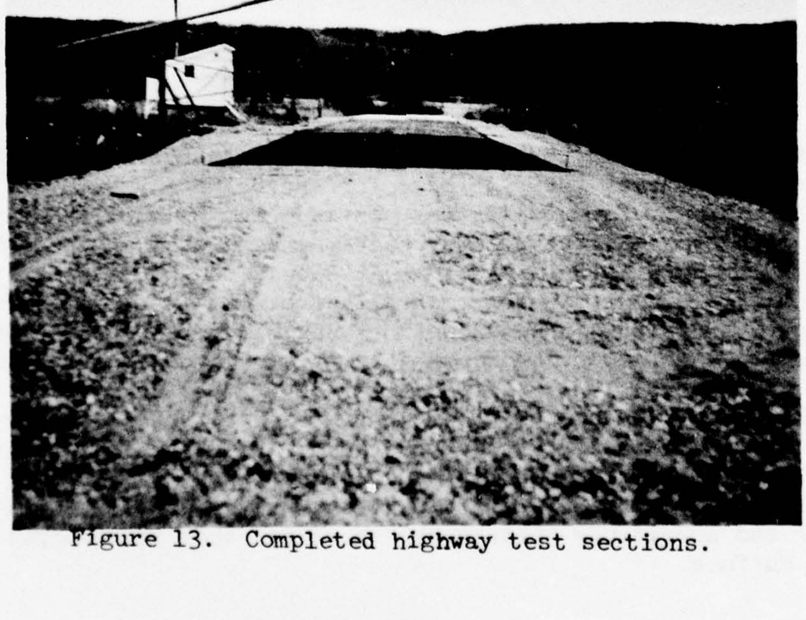

Figure 13. Completed highway test sections.

test sections. Surface subsidence and depth of the permafrost table were determined periodically over a period of eight years due to the change in the thermal regime only (Fig. 14)(Berg and Aitken 1973). The sections were not trafficked.

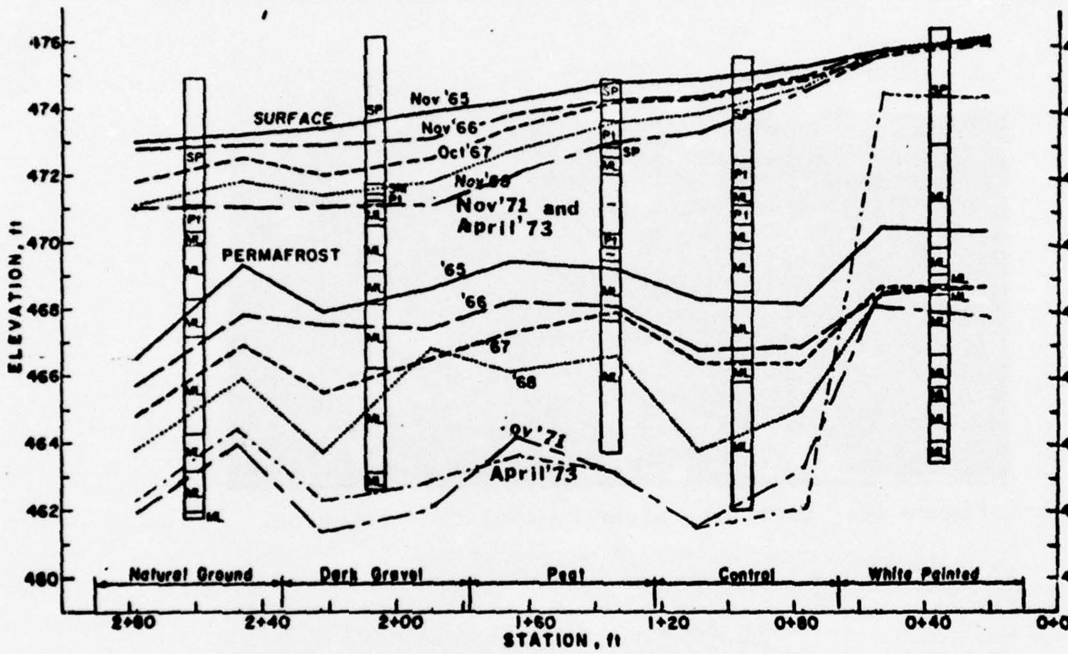

Figure 14. Highway test sections, permafrost degradation and surface subsidence.

As shown in Figure 14, embankments constructed under unfavorable permafrost conditions may not stabilize for approximately 8 to 10 years. In some instances settling may continue for as much as 20 years, because the thickness of most highway gravel embankments in central Alaska, excluding deep fills, is not great enough to insulate the permafrost. The high ice content of permanently frozen silt is widespread in central Alaska, and highways are sometimes unavoidably founded upon such permafrost. The amount of ice, which may vary from interstitial to massive, is responsible for differential settlement as thawing progresses. The normal staged construction practice of the Alaska Department of Highways is to continue regrading the gravel road and filling in low spots for about five years before even considering paving. Paving a highway, even after it has stabilized under a gravel surface, will cause more thawing and subsidence through the increased thermal absorption of the asphalt surface.

Figure 15 shows pavement failure on the Chena Hot Springs Road which was probably caused by degradation of underlying permafrost. This is one of many such failures noted along a five-mile section of this road. Figure 16 shows a section of the Richardson Highway where substantial subsidence of the pavement has occurred. Both the problems on the Chena

Figure 15. Pavement failure on Chena Hot Springs Road.

Figure 16. Undulation of pavement on Richardson Highway.

Hot Springs Road and the Richardson Highway may have been caused by disturbing the thermal regime in the subgrade. Staged construction would have allowed the degradation of the subgrade to stabilize before paving.

Figure 17, taken on the Elliott Highway, shows an embankment failure of a deep fill (approximately 15 ft) over a saddle. Severe road shoulder settlements and pavement cracking occurred on both sides of the road. Figure 18 shows a section of the Elliott Highway with a longitudinal crack that follows the center line. Tension cracks of this nature are

Figure 17. Embankment failure at road shoulder.

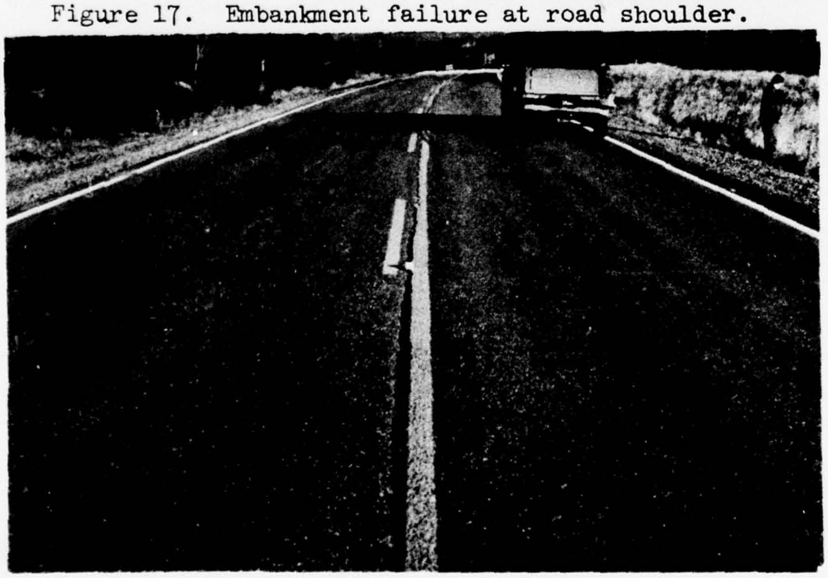

Figure 18. Longitudinal crack along center line.

prevalent in many places along Alaskan highways (as well as in more temperate regions). They permit intrusion of surface water into the embankment and result in subsequent failure. Some highway engineers have attributed these cracks to planes of weakness, resulting from paving one lane at a time with poor bonding between the two lanes.

Figure 19 shows pavement failure along the Elliott Highway. This embankment is apparently weak, as evidenced by the rutting. A high water table may be a contributing factor, as there is a stream nearby.

Figure 19. Pavement failure on the Elliott Highway.

Highway slope failures are constant maintenance problems in Alaska. Failures result from the entire spectrum of earth movements, ranging from massive rock slides to small mud failures that occur seasonally in some areas. Figure 20 shows the creep of a short section of the Steese Highway at mile 21. Erosion where sidehill cuts have been made is another continuing and serious highway maintenance problem.

Road Shoulder Failures

Each year subsidence and failure of road shoulders increase maintenance problems significantly. These problems result from a variety of causes, many of which are interrelated. For example, permafrost degradation at or under the embankment edge, contraction cracking, water intrusion, and frost action within the embankment shoulder are all

Figure 20. Creep on side hill on Steese Highway, mile 21.

interrelated phenomena and should not be treated as distinct and separate causes of slope failure.

Many instances of shoulder failure were observed during April and May of 1973. Figure 21 shows a typical slope failure along the Elliott Highway. In this case, high water and washout of the toe of the embankment caused cracking and subsequent sliding of the shoulder. Figures 22 and 23 show shoulder failure along the Trans-Alaska Pipeline Service (TAPS) road, and Figure 24 shows a similar failure on the Chena Hot Springs Road.

The above photographs illustrate but a few of many such failures observed. In cases in which failures are caused by permafrost degradation at or under the toe of the embankment, use of insulation such as polyurethane or polystyrene in and extending out from the shoulder might provide a solution (Fig. 25). Earth berms extending several yards from the embankment might also serve a useful purpose in preventing this type of failure.

Figure 21. Slope failure along the Elliott Highway

Figure 22. Shoulder failure along TAPS road

Figure 23. Longitudinal crack caused by settlement of embankment toe (TAPS road, mile 54.9).

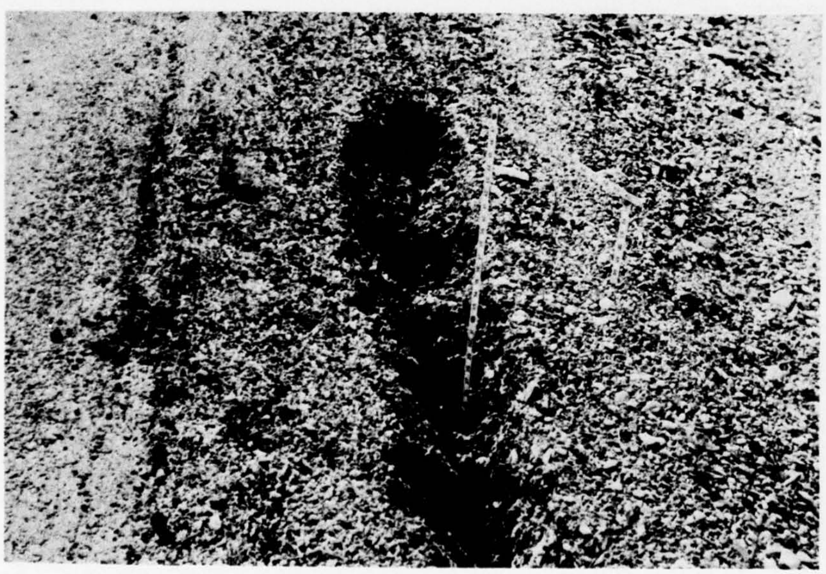

Figure 24. Shoulder failure caused by permafrost degradation under embankment toe (Chena Hot Springs Road, mile 12).

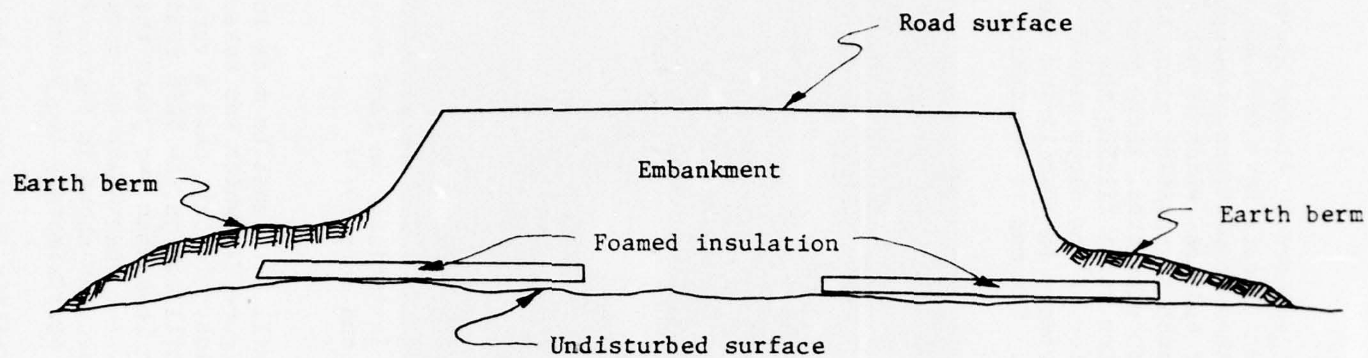

Figure 25. Use of foamed insulation to prevent shoulder failure.

Sidehill Cuts

Another problem of great concern to Alaska highway engineers is that of slope stability where sidehill cuts have been made, particularly through ice-rich permafrost. Under these conditions, the uphill slope degrades with an ensuing flow of water and mud, which if not corrected may continue for years. Figure 26 shows such a condition along the TAPS road. In this case it is interesting to note that, three years after initial construction, water and mud are still filling the uphill ditch with silt. The rock berm at the toe of the slope, placed there for the retention of the mud and for assistance in stabilizing the toe of the slope, is only partially successful. The mud is continuing to flow over or through the rock berm.

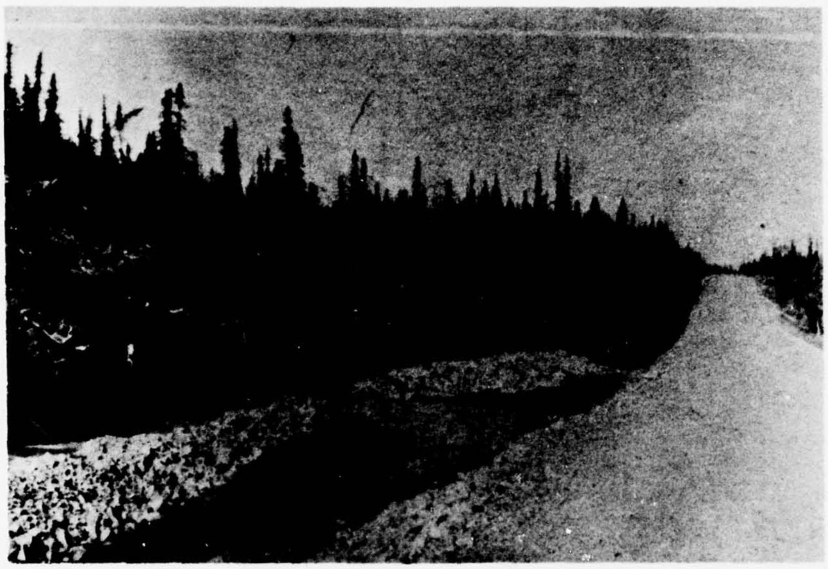

Figure 26. Slope instability on TAPS road (from Smith and Berg 1973).

In a few instances sidehill cuts must be made through virtually pure ice, such as shown in Figure 27, which was taken along the TAPS road shortly after construction. In this case a vertical cut was made. Figure 28 shows another sidehill cut on the TAPS roads. Subsequent observations revealed that in less than two years the ice had receded about 4 ft, the grasses and other vegetation had sloughed down over the ice, and the cut had stabilized, as shown in Figure 29 which was taken in the same general location approximately two years after construction.

The problem of slope stability is so serious that a concentrated research effort aimed at providing economical and practical solutions

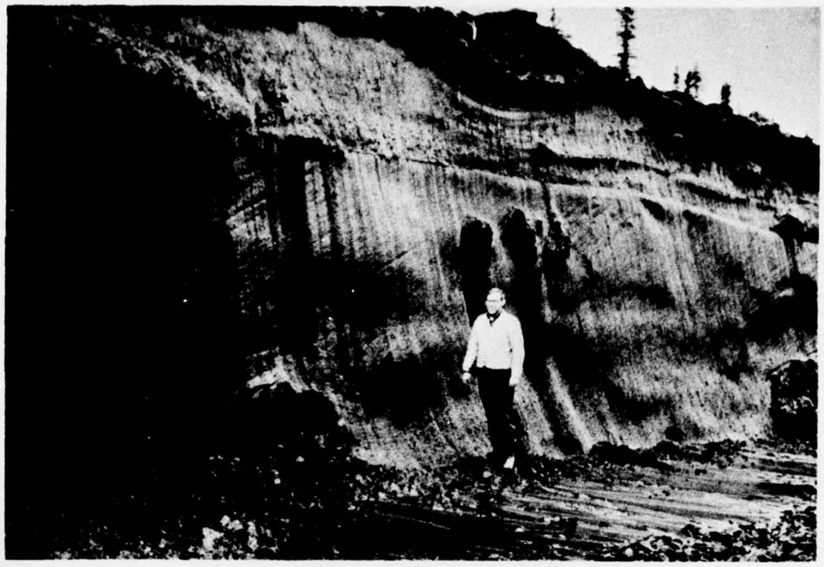

Figure 27. Vertical sidehill cut through ice at milepost 23.9 on TAPS road (from Smith and Berg 1973).

Figure 28. Vertical sidehill cut on TAPS road, 23 April 1970 (Smith and Berg 1973).

Figure 29. Same general location as shown in Figure 28 after approximately two years (photo. by N. Smith).

is considered to be justified. Research approaches might include identification and testing of fast growing plant species, use of organic mats to provide nutrients and conserve moisture, and use of gabions (wire baskets filled with rock) as shown in Figure 30.

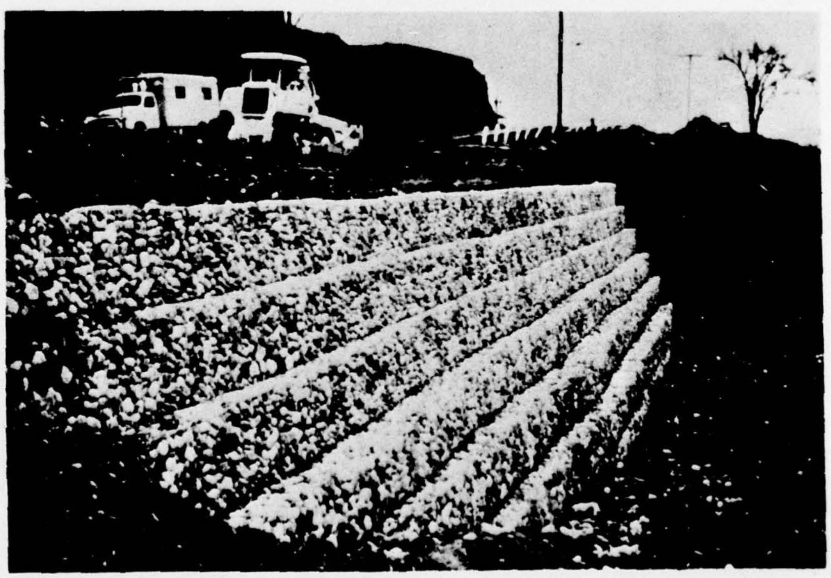

Figure 30. Gabions used to construct a retaining wall.

SECTION III - DRAINAGE AND HYDROLOGY

General

Many road failures in Alaska can be attributed to inadequate drainage. These problems are often due to the lack of information on the hydrologic regimes of specific areas, making proper design difficult.

Culvert Icing

One major drainage problem is that of culvert icing. Carey et al. (1973) and Carey (1974) reported on general culvert icing problems in Alaska and discussed some solutions developed by the Alaska Department of Highways, the Russians, and others. CRREL, in cooperative research with the Alaska Department of Highways, has experimented with electric heating cables, heating mats and fences, channel deepening, and channel covers. These studies have demonstrated quite clearly that there is no single solution to the problem. For example, electric heating cables may offer the best solution for locations where roadside power lines are present. However, in many locations electric power is not available and other solutions must be sought.

Another way of minimizing culvert icing is shown in Figure 31. The culverts may be placed at several elevations so that drainage may continue as the lower culvert freezes over. Icing over roadways occurs not only at the streams and culverts but also at side hills. Water seeps out of the upper slope and into the roadway where it freezes. Figure 32 shows a fence erected by the side of the road for control and containment of the freezing water. The Alaska Department of Highways prepared frostbelt areas at suitable sites to control icing. A frost belt area allows deep frost and icing to develop away from the road surface (Carey et al. 1975).

Embankment Damage by High Water

Hydrologic data are limited in many parts of Alaska. Each spring, during the high water period, some roads may sustain serious damage from roadside flooding. At the height of the spring melt, surface runoff is often extreme because the subsoil (including free draining ground) is still frozen. Figure 33 shows an excellent example of a roadway (TAPS mile 5.6) washout resulting from culverts unable to carry the accumulating volume of water. Ice was not involved in this situation, as both small culverts were carrying full flows of water.

Bridges

Design of bridges for Alaskan rivers and streams demands that consideration be given to stresses imposed by ice and debris, including

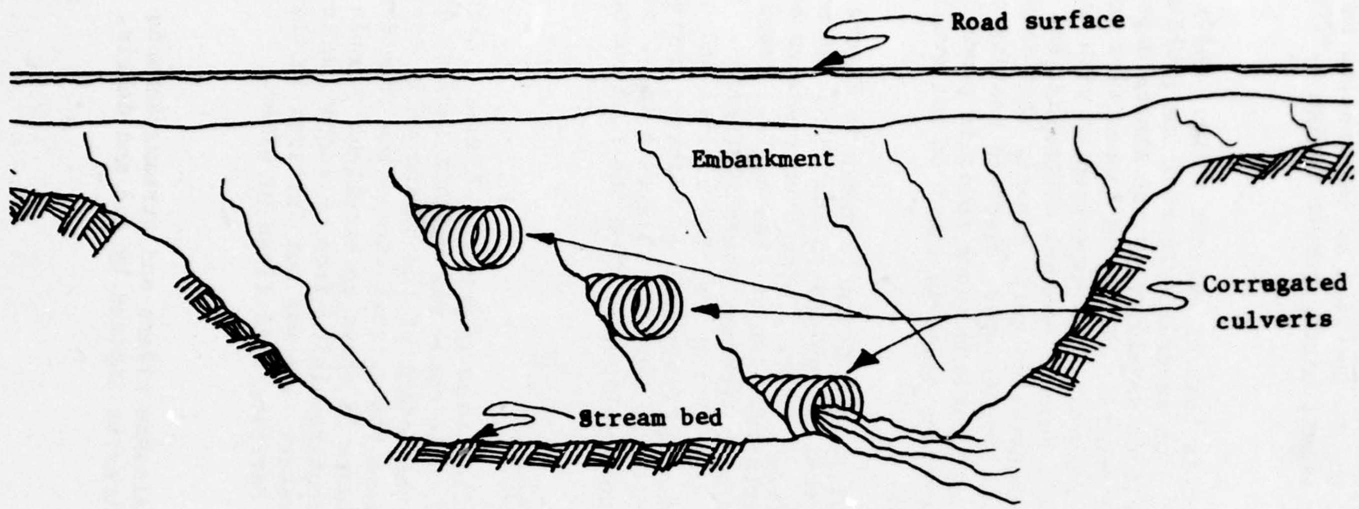

Figure 31. Schematic cross section of culverts at different elevations, used on Elliott and Richardson Highways.

Figure 32. Fence to control icing on the Richardson Highway near Paxson, Alaska.

Figure 33. Washout along TAPS road (mile 5.6).

those that occur during high water and ice breakup. During breakup the streams carry not only ice floes but also logs, brush, and other floating objects. Figure 34 (a photograph of Hess Creek, 1973) shows a typical assortment of ice floes and debris during the spring breakup.

Figure 34. Ice breakup at Hess Creek.

Figure 35 shows the Hess Creek bridge on the TAPS road. This is a pile bent bridge, constructed with "H" piles. The bents are probably

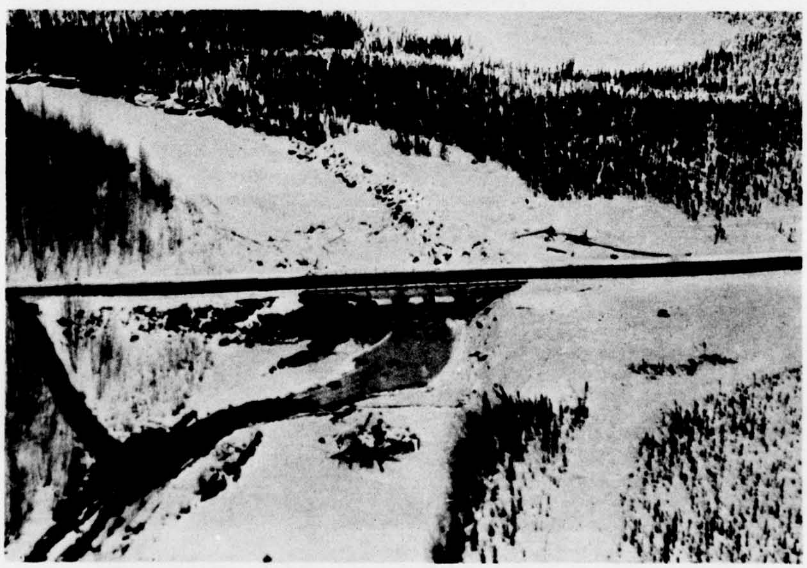

Figure 35. Hess Creek Bridge on TAPS road.

too close together, thus causing debris and ice buildup. Figures 36 and 37 show serious damage that this bridge sustained from log jams and repeated impacts from ice floes. Although unsuccessful at this location,

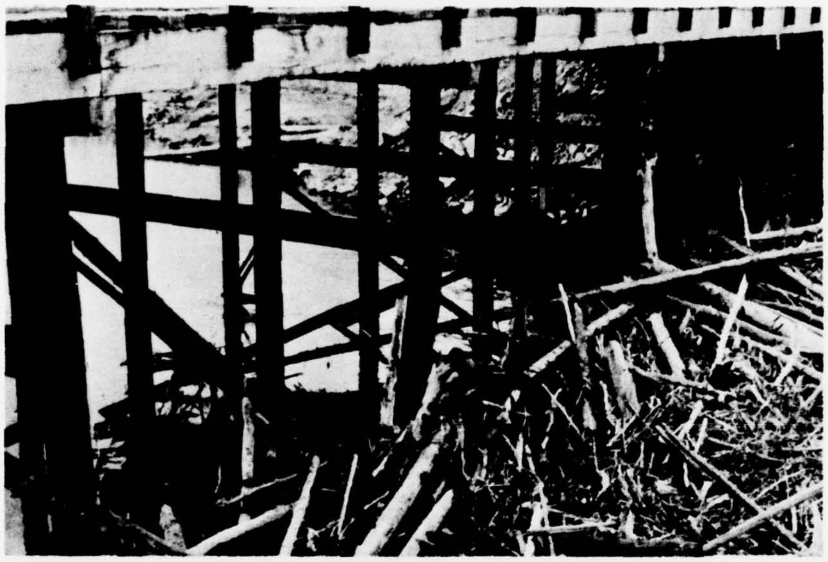

Figure 36. Damage to Hess Creek bridge from ice and debris during high water and ice breakup.

Figure 37. Closeup of damage to Hess Creek bridge.

deflection devices such as those used for a pile bent bridge across the Chena River on Fort Wainwright (Fig. 38) have been found useful for some bridges. These deflectors are constructed of "H" beams and placed approximately 15 ft upstream from the bents. A crane is used to clear debris from the deflectors.

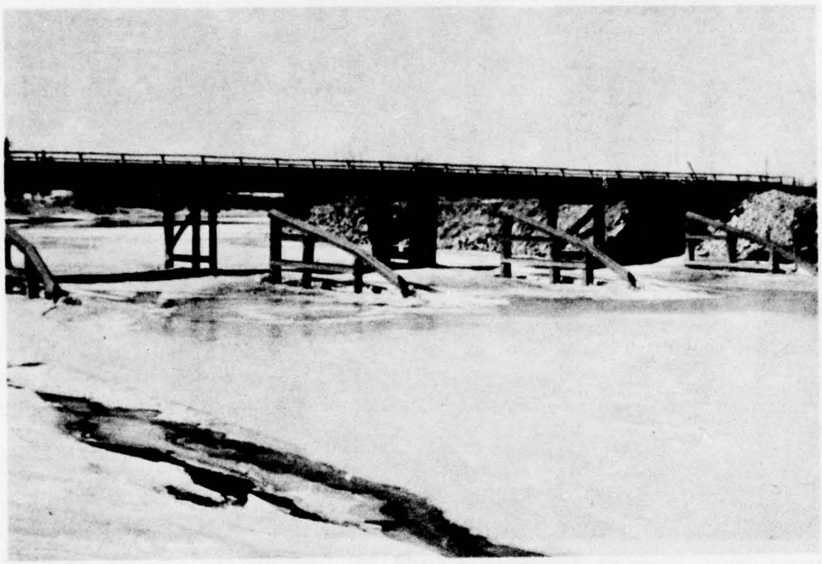

Figure 38. Ice and debris deflectors to protect bridge bents, Engineer Bridge, Fort Wainwright.

SECTION IV - SITE SELECTION

General

In the Arctic and Subarctic, site selection for new or rerouted roads is of major importance. Many of the construction and maintenance problems discussed in foregoing sections of this report could have been avoided by use of techniques that are currently available within the present state-of-the-art. In addition to considerations of the geological and hydrological characteristics of terrain, attention should be given to such factors as winter snowdrift patterns (particularly in heavy snowfall areas), natural icing conditions (winter growth of aufeis), erosion control, and slope stability. All these factors should be considered in terms of performance, maintenance difficulties, and life-cycle costs. In acquiring reliable data upon which to base analytical procedures leading to sound site selection, maximum use should be made of newly developed techniques and equipment.

Analytical studies will, however, often indicate that there is no perfect route. Usually the route must be the best of several possibilities and may contain some poor stretches.

Remote Sensing Equipment

Both remotely obtained panchromatic black and white and infrared imagery can be used advantageously in collecting information on locations where natural icings occur or where open water exists during the winter period. Also, valuable hydrological data during the spring melt and runoff season could be obtained by these means. Under certain conditions, color photography might provide useful information regarding vegetation, snow cover, and icing locations.

Other Considerations

There still is considerable controversy concerning road location on sidehills with respect to slope orientation, and particularly where sidehill cuts must be made through ice-rich soils. Some engineers advocate south-facing slopes where permafrost may not exist or where it will degrade rapidly. Others prefer north-facing slopes where the degradation of the permafrost will be retarded and accordingly settlement will be kept within tolerable limits. In the choice of slope location, the factors to be considered are sunlight on the road, and ice and snow melt. A definitive study of construction on north- and south-facing slopes would be worthwhile.

In many instances, environmental impact, land use rights, or time and funds available may leave very narrow latitude for highway engineers in selection of routes for new roads. Also, new roads must continue to service existing houses on the old routes. However, despite these obstacles, there can be little doubt that site selection is a very important factor in road design.

SECTION V - RECOMMENDATIONS FOR FUTURE RESEARCH

General

In 1975 approximately 3500 miles of paved road and 3500 miles of unpaved road were being maintained by the Alaska Department of Highways. However, it is estimated that the highway department is providing only 57% of the maintenance required to keep these roads in good condition (Parker 1976). The maintenance costs for Alaskan roads are high, compared to those for roads in the continental U.S., and the Alaskan tax base is inadequate to handle this expense.

The recent heavy use of Alaskan roadways due to construction of the Trans-Alaska Pipeline has greatly aggravated maintenance problems.

On some highways, such as the Richardson, it has been necessary to allow greater maximum loads than originally intended, with a resultant deterioration of the pavement (Brewer 1976). Annual traffic on Alaskan highways has increased by 112% since 1971, and truck traffic has increased by a factor of 6 (Alaska Construction and Oil 1975). Many Alaskan roadways have deteriorated rapidly due to inadequate construction. Maintenance problems have become so great that the Alaska Commissioner of Highways has predicted that, without increased Federal funding, many Alaskan roads will revert to being unpaved (Alaska Construction and Oil 1975).

Most Alaskan roads must undergo major rehabilitation every 10 years, and some must be rehabilitated every 5 years. The alternative is a road system with broken pavement and frost heaves - conditions that are already prevalent throughout the state and may continue in the foreseeable future. Clearly additional research into Alaskan road design is needed to help solve the state's transportation problems.

Both the Federal Highway Administration and the Alaska Department of Highways are cognizant of the need for research toward development of better solutions to major road construction and maintenance problems in northern environments. Each of these agencies, within available resources, has made efforts directed toward this objective. However, achievement of the order-of-magnitude improvement needed in road building technology requires additional research. New materials and construction equipment are becoming available commercially on almost a daily basis. To realize benefits from these developments and to bring arctic and subarctic road building design and construction criteria up-to-date with the equipment and materials state-of-the-art will require a concerted and cooperative team effort by all interested agencies.

Major Problem Areas

It is considered in this report that there are three major types of road construction problems in central Alaska for which acceptable solutions are needed urgently:

1) Use of frost-susceptible earth materials in road embankments. Some areas are far from non-frost-susceptible material. Savings in initial construction costs and in maintenance costs may be realized if methods and techniques are developed to obviate frost susceptibility in some soils.

2) Permafrost degradation under road enbankments and shoulders. A significant portion of road failures in Alaska result from permafrost degradation. Technology is available currently to prevent many of of these failures, but initial construction costs might be unacceptably high. Research aimed at lowering these costs is needed.

3) High water seasons and culvert icing. A more complete knowledge of hydrologic conditions in central Alaska is needed. More research into culvert and channel design should be conducted. Electric heating cables are only a partial solution to culvert icing problems. Many areas will not have electric power at roadside in the foreseeable future and other solutions must be sought.

There are, of course, many related and corollary problems for which solutions are needed. For example, improved site selection criteria would reduce the magnitude of some of these major problems. Erosion control would assist in solving drainage design problems, and use of thermoinsulating materials offers promise in solving the permafrost degradation problem.

Suggested Areas For Future Research

The following areas are suggested for future research:

1) Chemical stabilization of soils, both silts and organics, including tests of compounds to retard or eliminate moisture migration and to increase bonding strength.

2) Techniques or methods of using membranes to prevent moisture saturation of base course materials.

3) Use of the MESL method with organic and fine-grained soils.

4) Use of foamed insulation (polystyrene, etc.) to prevent embankment failure at shoulders, where founded on permafrost.

5) Use of berms to prevent degradation of permafrost under the toes of embankments.

6) Use of one-way insulators to inhibit or prevent degradation of underlying frozen materials.

7) Development of a means of preventing ground and culvert icing (e.g., multiple use of culverts at successively higher elevations in deep embankments; changing geometry of the stream bed at the upstream end, use of convection-type heat tubes).

8) Use of gabions to stabilize slopes and develop rapid mechanical means of filling and emplacing them.

9) Use of fast growing plants to revegetate slopes.

10) Use of organic materials sprayed on slopes to retain moisture and fertilize new vegetation stands.

11) Development of methods for terracing slopes to prevent erosion (with use of such means as brush bundles to serve as retaining walls).

12) Development of various applications of remote sensing for site selection.

13) Development of methods or materials for pavement design and placement to eliminate thermal cracking.

14) Research on methods for reinforcing roadbeds and pavements to preclude crack formation.

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